DRAFT

Chad Demarest
New England Fishery Management Council

A conceptual model for cumulative effects analysis

Cumulative effects assessments conducted under the National Environmental Policy Act (NEPA) are required for most fisheries management actions. Extant guidance focuses primarily on the underlying principals and potential methods for carrying out these analyses (CEQ 1997, EPA 1997). What is missing is an explicit description of the relationships between the various analytic elements required for a fully specified cumulative effects analysis (CEA). To this end, a three-step process for conducting CEA is presented here.

Step 1: Establish baseline conditions specific to a VEC, indicator and place

"Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected" (CEQ 1997). NEPA literature has termed these resources, ecosystems and human communities Valued Ecosystem Components, or VECs (Beanlands and Duinker 1984, Hegmann, *et. al.* 1997). These VECs are intended to serve as the backbone of a CEA.

In both quantitative and qualitative assessments, a given VEC should be comprised of a series of indicators *i*, for which baseline conditions throughout a region *r* at time *t* may be calculated as the sum of some explicitly defined initial condition to which the impacts of endogenous actions (those occurring within the management sphere, superscript *n*) and exogenous actions (those occurring outside the management sphere, superscript *e*) are added. This is represented as:

$$(1)\ \beta_{i,\,r} = I_{i,\,t,\,r} + \Sigma\, f(P^n, F^n)_{i,\,t,\,r}\, f(P^e, C^e, F^e)_{i,\,t,\,r}$$

$$i = 1, 2, 3\ldots, n;\ j = 1, 2, 3\ldots, n;\ r = 1, 2, 3\ldots, n;\ t = 0, 1, 2, 3,\ldots x\ldots, n$$

where $\beta_{i,\,t,\,r}$ defines the baseline conditions at time $t=x$, I defines the initial conditions at time $t=0$, P is the effect of past actions (when $0 < t < x$), C is the effect of current actions at time $t=x$, and F is the effect of reasonably foreseeable future actions (when $x < t < n$).

The functions f (P, F) and f (P, C, F) are arithmetic and may represent synergistic and/or countervailing impact affects. Note that P and F apply to both endogenous and exogenous actions, while C applies only to exogenous actions. This is because the current endogenous action is the management action, the impacts of which are addressed in Step 2. Note also that "actions" are defined as any project or activity of human origin (Hegmann *et. al.* 1997, CEQ 1999, EPA 1999).

This step can serve as an outline for the Affected Environment section of an EA or EIS.

Step 2: Estimate cumulative effects of the alternatives

The cumulative effect is the difference between the post-action cumulative condition and the baseline conditions. The post-action cumulative condition is represented as a function of the baseline conditions and the effect of alternative μ:

$$(2)\ CC_{\mu,\,i,\,r} = f(\beta_{\,i,\,r},\ \Phi_{\mu})$$

$$(3)\ CE_{\mu,\,i,\,r} = CC_{\mu,\,i,\,r} - \beta_{i,\,r}$$

where *CC* is the post-action cumulative condition, Φ is the effect of alternative μ, and *CE* is the cumulative effect.

Calculating the post-action cumulative condition is necessary for determining the overall potential significance of a proposed action or alternative. Calculating the discrete cumulative effect allows for comparisons between the direct and cumulative effects of an alternative.

Step 2 is an outline for the Environmental Consequences/Effects section of an EA or EIS.

Step 3: Determine the significance of the effect

To determine if the cumulative effects are significant, the effect should be compared to an *a priori*-defined desired condition. For a relative significance determination, a ratio of the post-action cumulative condition to some acceptable level of degradation may be calculated:

$$(4)\ \Omega = CC_{\mu,\,i,\,r} / k_{\,i,\,r} \quad \text{and,}$$

$$(5)\ k_{\,i,\,r} = \theta_{\,i,\,r} - \alpha$$

where Ω is a relative significance ratio, k is the significance threshold, θ is the desired condition, and α is some acceptable level of degradation from θ

If higher positive numbers equate to more desired conditions, ratios greater than one will indicate no significant effect; ratios less than one indicate effects that are potentially significant. Because ratios are unit less, they may be compared across alternative, VEC, and indicator to show relative deviations from desired conditions. Furthermore, it may be useful as a summary measure to average the ratios across VECs or alternatives to provide composite deviations from desired conditions on a per-VEC or per-alternative basis.

At this point in time, Step 3 is largely academic. While it is the approach described in the CEQ guidelines (see CEQ 1999 pages 7 and 17), it is markedly different from guidance provided in NOAA Administrative Order 216-6. As issues surrounding delineating thresholds and desired conditions are subjective and have a social engineering component, for the time being it seems appropriate to follow the guidance in AO 216-6 instead of Step 3. It should be noted that CEQ guidance addresses this issue explicitly by stating that "these thresholds and desired conditions can best be defined by the cooperative efforts of agency officials, project proponents, environmental analysts, non-governmental organizations, and the public through the NEPA process."

Literature Cited

Beanlands, G. and P.N. Duinker. 1984. "An Ecological Framework for Environmental Impact Assessment." *Journal of Environmental Management,* Vol. 18: 264-277.

Hegmann, G., Cocklin, C., Creasey, R., Dupuis, S., Kennedy, A., Kingsley, L., Ross, W., Spaling, H., and Stalker, D., "Cumulative Effects Assessment Practitioner's Guide," February, 1999, Canadian Environmental Assessment Agency, Hull, Quebec, Canada.

Council on Environmental Quality 1997. "Considering Cumulative Effects Under the National Environmental Policy Act," January 1997, Executive Office of the President, Washington, D.C.

EPA. 1999. "Consideration of Cumulative Effects in EPA Review of NEPA Documents". 1999. Office of Federal Activities, EPA, Washington DC

Appendix A – Cumulative Effects and Significance Determinations

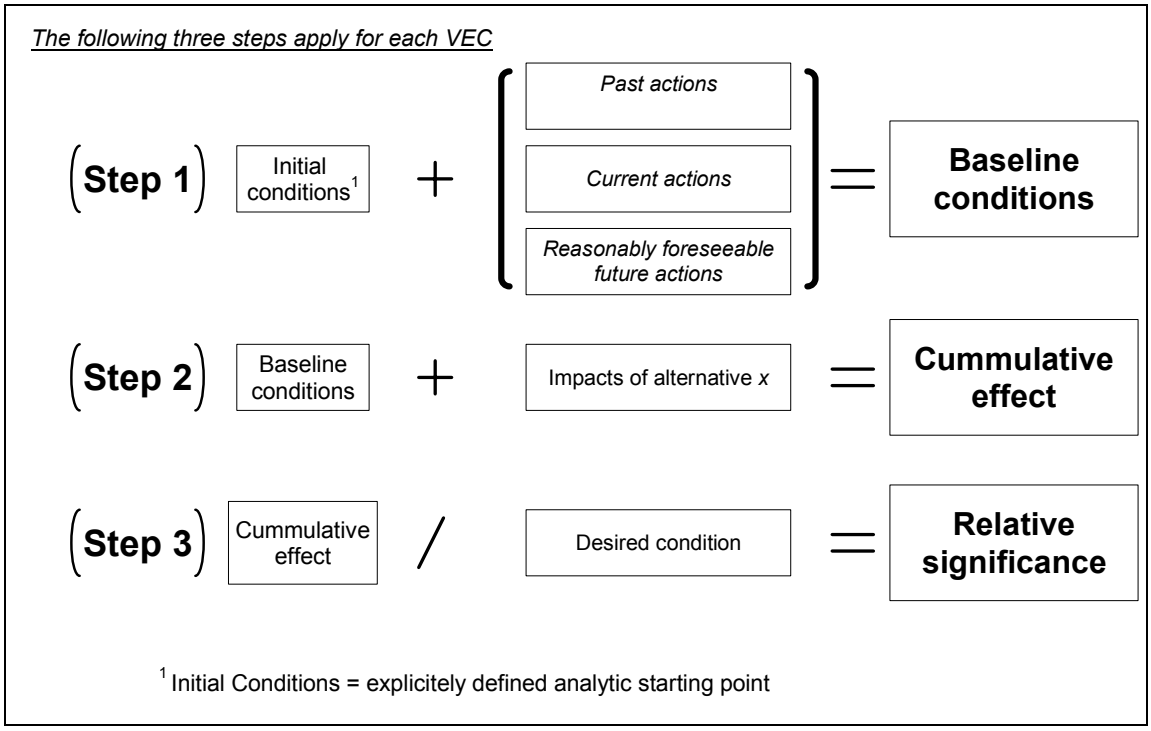

Figure 1 – Simplified conceptual model of cumulative effects analysis

Appendix B – Concepts Introduced

New concepts introduced: *initial conditions, endogenous effects, exogenous effects, relative significance ratio, post-action cumulative condition.*

Concepts introduced by CEQ but not yet widely adopted: *baseline conditions, thresholds, desired conditions.*